

CLAIMS

1. A control device comprising:

a housing;

5 a carrier coupled to said housing and operative to move with respect to said housing in a first rotary degree of freedom;

a first sensor coupled to said carrier and operative to sense said movement of said carrier, said first sensor outputting a first control signal;

10 a roller rotatably coupled to said carrier such that said roller rotates with said carrier about said first rotary degree of freedom, said roller operative to rotate with respect to said carrier in a second rotary degree of freedom; and

a second sensor coupled to said roller and operative to sense rotary motion of said roller in said second rotary degree of freedom, said second sensor outputting a second control signal.

15

2. A control device as recited in claim 1 further comprising an arm member coupled between said carrier and said housing, said arm member rotatably coupled to said housing, wherein said first sensor senses rotation of said arm member.

20 3. A control device as recited in claim 2 wherein said arm member is positioned in said housing and wherein said housing includes an aperture through which said carrier and said roller are accessible to a user of said control device.

4. A control device as recited in claim 2 further comprising a third sensor coupled to said housing, said third sensor detecting when said carrier has been pushed in a direction substantially orthogonal to a plane of rotation of said arm member.

25 5. A control device as recited in claim 2 wherein said roller is operative to rotate about an axis that is parallel to a plane of rotation of said arm member.

6. A control device as recited in claim 5 wherein said roller is a first roller, and further comprising:

a second roller rotatably coupled to said carrier and operative to rotate with respect to said carrier independently of said first roller,

a third sensor coupled to said third roller and operative to sense rotary motion of said third roller, said third sensor outputting a third control signal.

5 7. A control device as recited in claim 2 wherein said roller is a first roller, and further comprising a second roller rotatably coupled to said carrier and operative to rotate with respect to said carrier, and a belt coupled between said first roller and said second roller, said belt being accessible to contact by said user.

10 8. A control device as recited in claim 2 further comprising a rotating member coupled to said housing and extending from a bottom plate of said housing, such that said rotating member contacts a flat surface and rotates when said control device is moved over said flat surface.

15 9. A control device as recited in claim 1 wherein said carrier is coupled to said housing by contact bearings which sit in tracks on said housing and allow said carrier to move along said tracks.

 10. A control device as recited in claim 1 wherein said roller is provided within an aperture of said carrier such that a surface of said carrier surrounds all sides of said roller.

20 11. A control device as recited in claim 1 further comprising:
a first actuator coupled to said arm member and operative to output a force on said carrier in said degree of freedom of said carrier; and

a second actuator coupled to said roller and operative to output a force on said roller in said rotary degree of freedom.

25 12. A control device as recited in claim 1 wherein said first sensor and said second sensor are optical sensors.

 13. A force feedback control device in communication with a host computer, implementing a graphical environment, the force feedback control device comprising:

a housing;

an arm rotatably coupled to said housing and operative to move with respect to said housing in a degree of freedom;

a first sensor coupled to said arm and operative to sense said movement of said arm, said first sensor outputting a first control signal;

5 a first actuator coupled to said arm and operative to output a force to said arm in said degree of freedom, said first actuator being controlled by a first actuator signal;

a roller rotatably coupled to said arm and operative to rotate with respect to said arm in a rotary degree of freedom;

10 a second sensor coupled to said roller and operative to sense rotary motion of said roller, said second sensor outputting a second control signal; and

a second actuator coupled to said roller and operative to output a force to said roller in said rotary degree of freedom, said second actuator being controlled by a second actuator signal.

15 14. A force feedback control device as recited in claim 13 wherein said arm member is positioned in said housing and wherein said housing includes an aperture through which said roller is accessible to a user of said control device.

20 15. A force feedback control device as recited in claim 13 further comprising a third sensor coupled to said housing, said third sensor detecting when said roller has been pushed in a direction substantially orthogonal to a plane of rotation of said arm member.

16. A force feedback control device as recited in claim 13 wherein said roller is operative to rotate about an axis that is parallel to a plane of rotation of said arm member.

25 17. A force feedback control device as recited in claim 13 wherein said first actuator is grounded to said housing and wherein said second actuator is carried by said arm member.

18. A method for interfacing with an apparatus using signals provided by a control device, the method comprising:

30 providing a first sensor signal from a first sensor to said apparatus, said first sensor signal being representative of a position of an arm in a first rotary degree of

freedom, wherein said arm is moved in said first rotary degree of freedom by a finger of a user; and

providing a second sensor signal from a second sensor, said second sensor signal being representative of a position of a roller in a second rotary degree of freedom, said roller being rotatably coupled to said arm, wherein said roller is rotated in said second rotary degree of freedom by said finger of said user.

19. A method as recited in claim 18 further comprising receiving a force feedback signal from said apparatus and providing said force feedback signal to an actuator that is coupled to said roller, said force feedback signal being based at least in part on said first sensor signal and said second sensor signal.

20. A method as recited in claim 19 wherein said actuator is a first actuator and said force feedback signal is a first force feedback signal, and further comprising receiving a second force feedback signal from said apparatus and providing said second force feedback signal to a second actuator that is coupled to said arm, said second force feedback signal being based at least in part on said first sensor signal and said second sensor signal.

21. A method as recited in claim 18 wherein said apparatus includes a host computer including a display screen, wherein a user-controlled cursor is displayed on said display screen having a position determined by said first sensor signal and said second sensor signal.

22. A method as recited in claim 18 wherein said apparatus includes a host computer displaying a graphical environment including at least one graphical object and a user controlled cursor, wherein said cursor is displayed in said graphical environment at a position determined by said first sensor signal and said second sensor signal, and wherein said first and second force feedback signals are determined at least in part based on an interaction of said cursor with said graphical object.